



**NSAI**  
Standards

Irish Standard  
I.S. EN ISO 6416:2017

# Hydrometry - Measurement of discharge by the ultrasonic transit time (time of flight) method (ISO 6416:2017)

## I.S. EN ISO 6416:2017

*Incorporating amendments/corrigenda/National Annexes issued since publication:*

The National Standards Authority of Ireland (NSAI) produces the following categories of formal documents:

I.S. xxx: Irish Standard — national specification based on the consensus of an expert panel and subject to public consultation.

S.R. xxx: Standard Recommendation — recommendation based on the consensus of an expert panel and subject to public consultation.

SWiFT xxx: A rapidly developed recommendatory document based on the consensus of the participants of an NSAI workshop.

*This document replaces/revises/consolidates the NSAI adoption of the document(s) indicated on the CEN/CENELEC cover/Foreword and the following National document(s):*

*NOTE: The date of any NSAI previous adoption may not match the date of its original CEN/CENELEC document.*

*This document is based on:*

EN ISO 6416:2017

*Published:*

2017-11-29

*This document was published  
under the authority of the NSAI  
and comes into effect on:*

2017-12-17

ICS number:

17.120.20

NOTE: If blank see CEN/CENELEC cover page

NSAI  
1 Swift Square,  
Northwood, Santry  
Dublin 9

T +353 1 807 3800  
F +353 1 807 3838  
E standards@nsai.ie  
W NSAI.ie

Sales:  
T +353 1 857 6730  
F +353 1 857 6729  
W standards.ie

Údarás um Chaighdeáin Náisiúnta na hÉireann

## National Foreword

I.S. EN ISO 6416:2017 is the adopted Irish version of the European Document EN ISO 6416:2017, Hydrometry - Measurement of discharge by the ultrasonic transit time (time of flight) method (ISO 6416:2017)

This document does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

For relationships with other publications refer to the NSAI web store.

**Compliance with this document does not of itself confer immunity from legal obligations.**

*In line with international standards practice the decimal point is shown as a comma (,) throughout this document.*

This page is intentionally left blank

EUROPEAN STANDARD

EN ISO 6416

NORME EUROPÉENNE

EUROPÄISCHE NORM

November 2017

ICS 17.120.20

Supersedes EN ISO 6416:2005

English Version

## Hydrometry - Measurement of discharge by the ultrasonic transit time (time of flight) method (ISO 6416:2017)

Hydrométrie - Mesure du débit par la méthode du temps de transit ultrasonique (temps de vol) (ISO 6416:2017)

Hydrometrie - Messung des Durchflusses mit dem Ultraschall-Laufzeitverfahren (Transit-time-/Time-of-flight-Verfahren) (ISO 6416:2017)

This European Standard was approved by CEN on 22 August 2017.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

**EN ISO 6416:2017 (E)**

<b>Contents</b>	<b>Page</b>
<b>European foreword.....</b>	<b>3</b>

## **European foreword**

This document (EN ISO 6416:2017) has been prepared by Technical Committee ISO/TC 113 “Hydrometry” in collaboration with Technical Committee CEN/TC 318 “Hydrometry” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2018, and conflicting national standards shall be withdrawn at the latest by May 2018.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 6416:2005.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

### **Endorsement notice**

The text of ISO 6416:2017 has been approved by CEN as EN ISO 6416:2017 without any modification.

This page is intentionally left blank



# INTERNATIONAL STANDARD

**ISO  
6416**

Fourth edition  
2017-10

---

---

## **Hydrometry — Measurement of discharge by the ultrasonic transit time (time of flight) method**

*Hydrométrie — Mesure du débit par la méthode du temps de transit  
ultrasonique (temps de vol)*



Reference number  
ISO 6416:2017(E)

© ISO 2017

**ISO 6416:2017(E)**



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2017, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Ch. de Blandonnet 8 • CP 401  
CH-1214 Vernier, Geneva, Switzerland  
Tel. +41 22 749 01 11  
Fax +41 22 749 09 47  
copyright@iso.org  
www.iso.org

# Contents

Page

<b>Foreword</b>	<b>v</b>
<b>1 Scope</b>	<b>1</b>
<b>2 Normative references</b>	<b>1</b>
<b>3 Terms and definitions</b>	<b>1</b>
<b>4 Applications</b>	<b>1</b>
4.1 Types of applications	1
4.2 Attributes and limitations	2
<b>5 Method of measurement</b>	<b>2</b>
5.1 Discharge	2
5.2 Calculation of discharge from the transit-time measurement	3
<b>6 Flow velocity determination by the ultrasonic (transit time) method</b>	<b>3</b>
6.1 Principle	3
6.2 Sound propagation in water	5
6.2.1 General	5
6.2.2 Speed of sound in water	6
6.2.3 Propagation losses	6
6.2.4 Signal path bending	8
6.2.5 Reflection	9
<b>7 Gauge configuration</b>	<b>10</b>
7.1 General	10
7.2 Single-path systems	10
7.3 Multi-path systems	11
7.4 Crossed-path systems	11
7.5 Reflected-path systems	13
7.6 Systems using transponders	14
7.7 Wireless systems (if a cable crossing is not possible)	15
7.8 Systems using divided cross-sections	16
7.9 Sloping paths	16
<b>8 Determination of discharge</b>	<b>17</b>
8.1 Single-path systems	17
8.2 Multi-path systems	18
8.2.1 General	18
8.2.2 Mid-section method	19
8.2.3 Mean-section method	20
8.3 Systems with transducers in the channel	21
<b>9 System verification and calibration</b>	<b>22</b>
<b>10 Site selection</b>	<b>23</b>
<b>11 Site survey — Before design and construction</b>	<b>23</b>
11.1 General	23
11.2 Visual survey	23
11.3 Survey of the cross-section	24
11.4 Survey of velocity distribution	24
11.5 Survey of signal propagation	24
<b>12 Operational measurement requirements</b>	<b>24</b>
12.1 General	24
12.2 Basic components of flow determination	25
12.3 Water velocity determination	25
12.4 Determination of water stage or depth	25
12.5 Determination of mean bed level	26
12.6 Channel width	27

## ISO 6416:2017(E)

<b>13</b>	<b>Gauging station equipment</b>	<b>27</b>
13.1	General	27
13.2	Design and construction of equipment	28
13.2.1	Transducers	28
13.2.2	Transducer cables	29
13.3	Reflectors	29
13.4	Civil engineering works	32
13.5	Signal timing and processing	32
13.5.1	General	32
13.5.2	Signal-to-noise ratio	32
13.5.3	Signal maintenance (gain control)	33
13.5.4	Signal detection	33
13.5.5	Post-detection filtering	34
13.6	System self-checking	34
13.7	Site-specific data (or site parameters)	35
13.8	Clock and calendar	35
13.9	System performance criteria	35
13.9.1	General	35
13.9.2	Operating environment	36
13.9.3	Water environment	36
13.9.4	Mechanical environment	36
13.9.5	Extreme environmental conditions	36
13.9.6	Power source	36
13.9.7	Measurement uncertainty	36
13.10	System output	37
13.10.1	Local display	37
13.10.2	Local record	37
13.10.3	Remote record	37
13.10.4	Diagnostic information	37
13.11	Installation	37
13.12	Commissioning	38
13.13	Operating manual	38
13.14	Maintenance	39
<b>14</b>	<b>Measurement uncertainties</b>	<b>40</b>
14.1	General	40
14.2	Definition of uncertainty	40
14.3	Uncertainty in discharge	41
14.3.1	Uncertainty equation	41
14.3.2	Effective number of paths	42
14.3.3	Uncertainty in the line velocity, $U_{lv}$	42
14.3.4	Uncertainty in the channel width estimation, $U_w$	42
14.3.5	Examples of uncertainty estimation	43
14.3.6	Uncertainty estimate at low flow	44
14.3.7	Uncertainty estimate at high flow	45
<b>Annex A (informative)</b>	<b>Principle of measurement uncertainty</b>	<b>47</b>
<b>Annex B (informative)</b>	<b>Performance guide for hydrometric equipment for use in technical standard examples</b>	<b>54</b>
<b>Bibliography</b>		<b>58</b>

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 1, *Velocity area methods*.

This fourth edition cancels and replaces the third edition (ISO 6416:2004), which has been technically revised. The main changes from the previous edition are:

- the title has been changed;
- a new [subclause \(7.7\)](#) on wireless systems has been added;
- former subclauses 9.2 and 11.6 have been removed;
- [Clause 10](#) on site selection has been revised;
- [Annex A](#) (*Principle of measurement uncertainty*) and [Annex B](#) (*Performance guide for hydrometric equipment for use in technical standards*) have been added.



# Hydrometry — Measurement of discharge by the ultrasonic transit time (time of flight) method

## 1 Scope

This document describes the establishment and operation of an ultrasonic (transit-time) gauging station for the continuous measurement of discharge in a river, an open channel or a closed conduit. It also describes the basic principles on which the method is based, the operation and performance of associated instrumentation and procedures for commissioning.

It is limited to the “transit time of ultrasonic pulses” technique, and is not applicable to systems that make use of the “Doppler shift” or “correlation” or “level-to-flow” techniques.

This document is not applicable to measurement in rivers with ice.

**NOTE** This document focuses on open channel flow measurement. IEC 60041 covers the use of the technique for full pipe flow measurement.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometry — Vocabulary and symbols*

ISO 4373, *Hydrometry — Water level measuring devices*

ISO/TS 25377, *Hydrometric uncertainty guidance (HUG)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

## 4 Applications

### 4.1 Types of applications

- a) Open channels
- b) Multiple channels
- c) Closed conduits

This method does not need a man-made or natural control, as it does not rely upon the establishment of a unique relationship between water level and discharge.

This is a free preview. Purchase the entire publication at the link below:

[Product Page](#)

- 
- Looking for additional Standards? Visit Intertek Inform Infostore
  - Learn about LexConnect, All Jurisdictions, Standards referenced in Australian legislation
-